National Aeronautics and
Space Administration

March 2012 Mw 7.4 Ometepec and February 2018 Mw 7.2 Pinotepa Earthquakes in Mexico Ruptured Small Patches of the Cocos Megathrust

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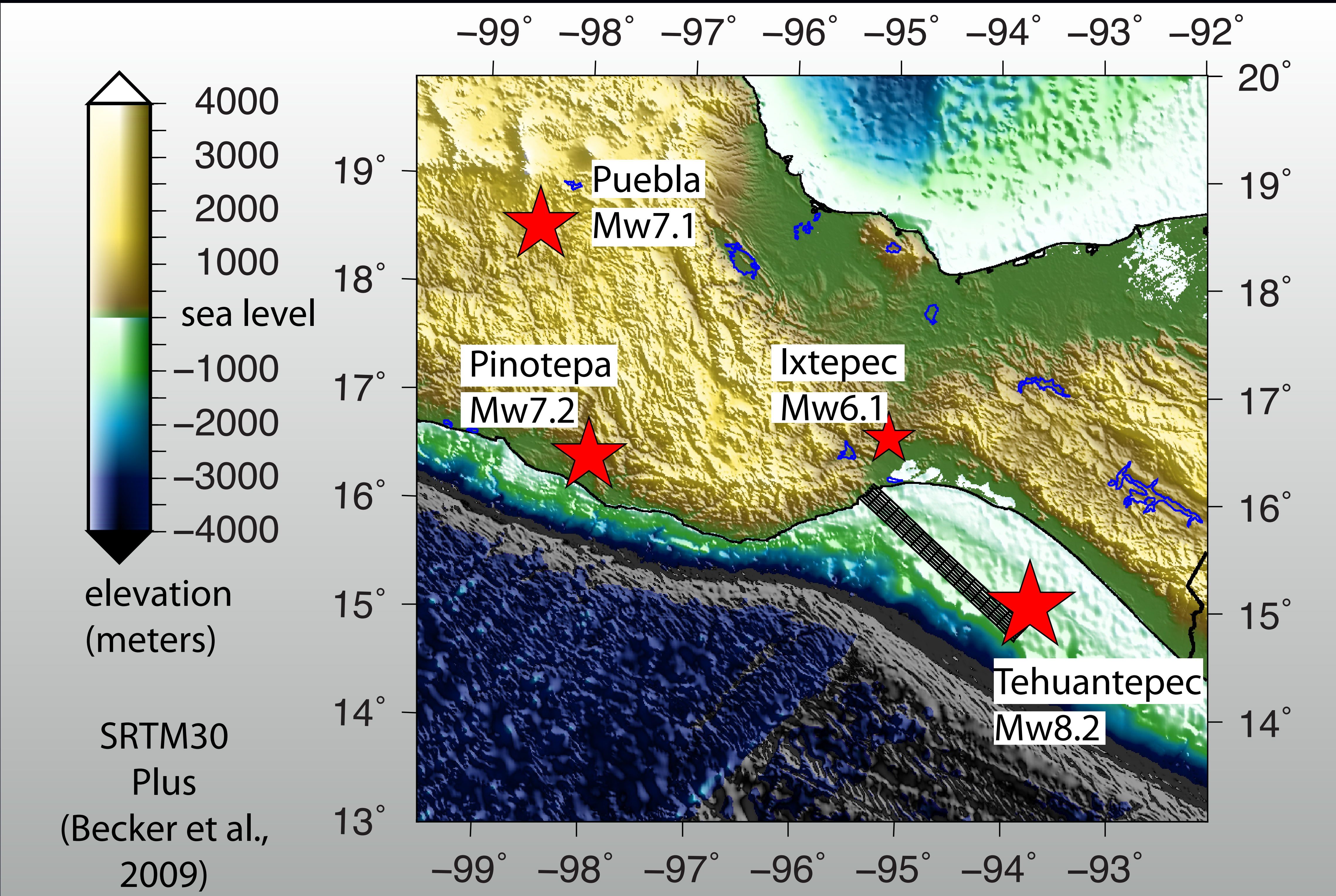
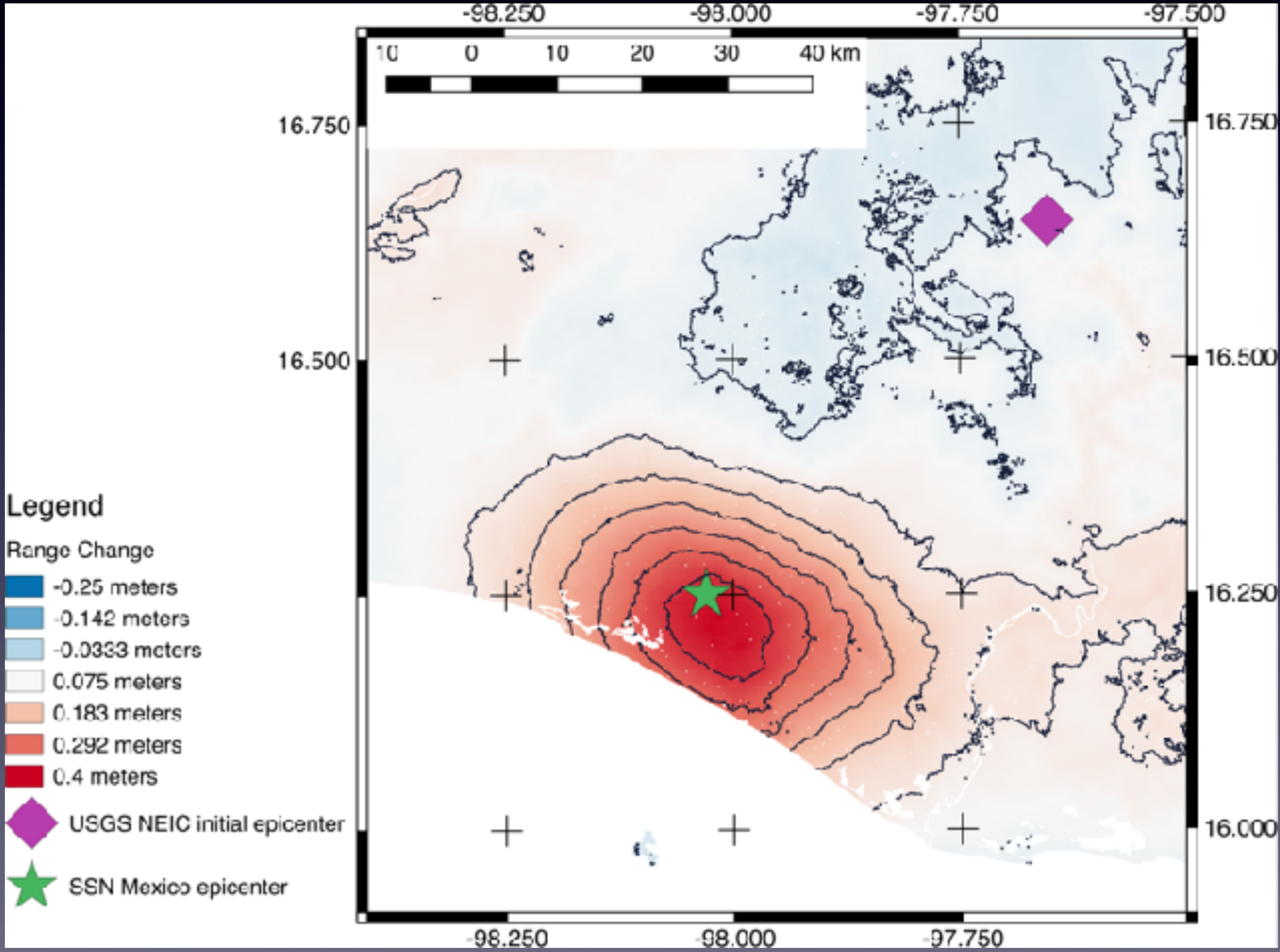
Southern Mexico 2017–2018



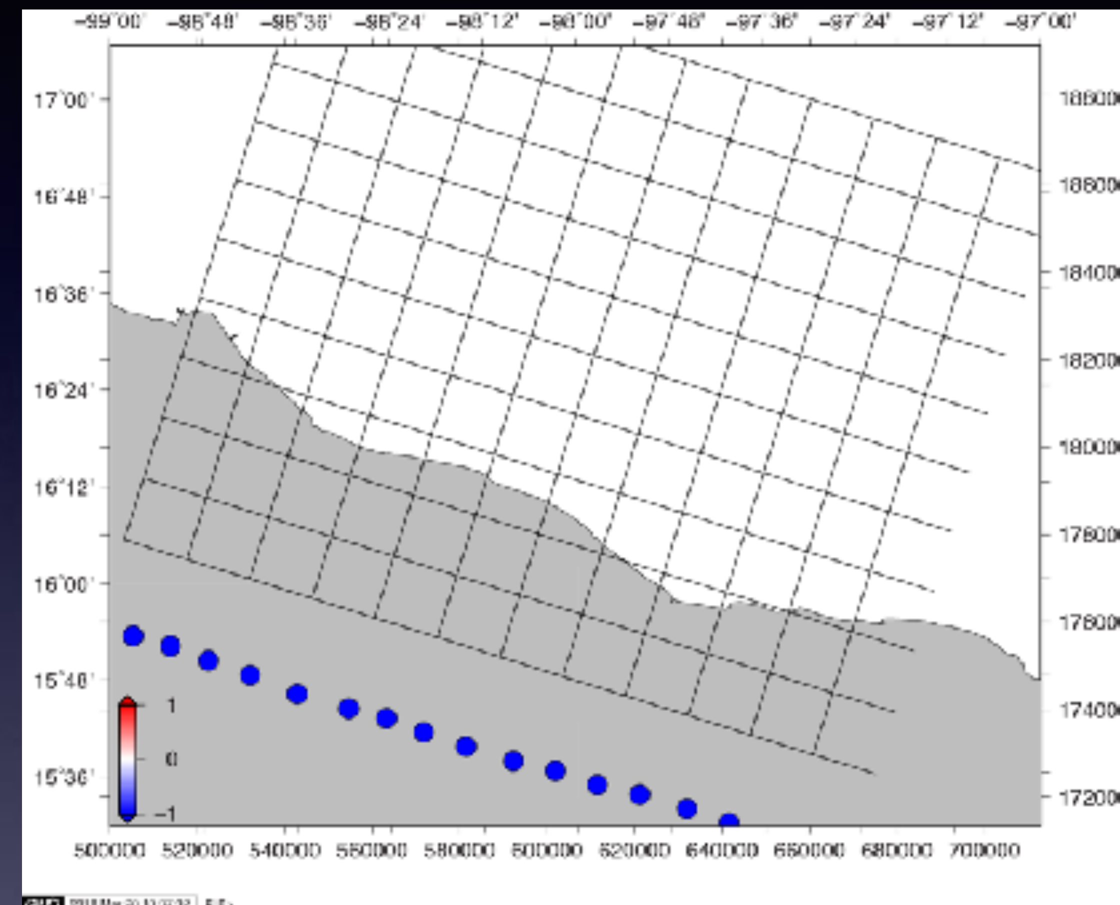
2018 Mw 7.2 Pinotepa Earthquake

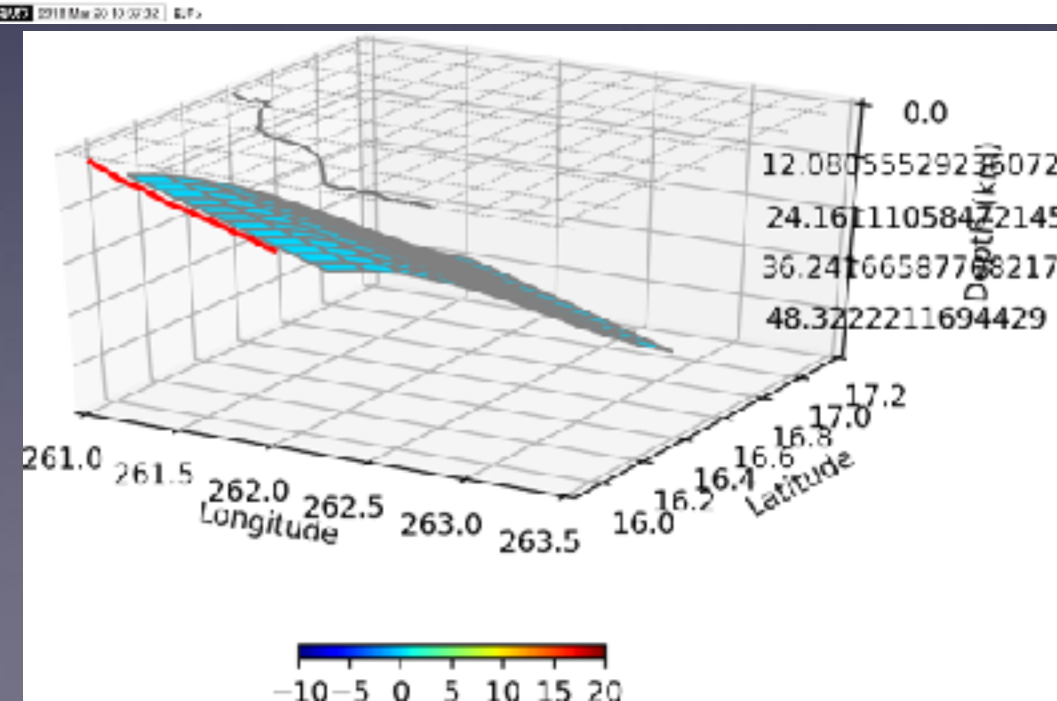
- Megathrust rupture 16 February 2018 near Pinotepa Nacional, Oaxaca
- Sentinel-1 SAR image acquired 1 hour after earthquake
- Interferogram automatically processed by ARIA data system ~12 hours after earthquake
- Initial USGS NEIC epicenter ~40 km to NW of InSAR
- Sent initial interferogram to USGS to inform hypocenter used in finite fault model and revised ShakeMap



Pinotepa slip modeling

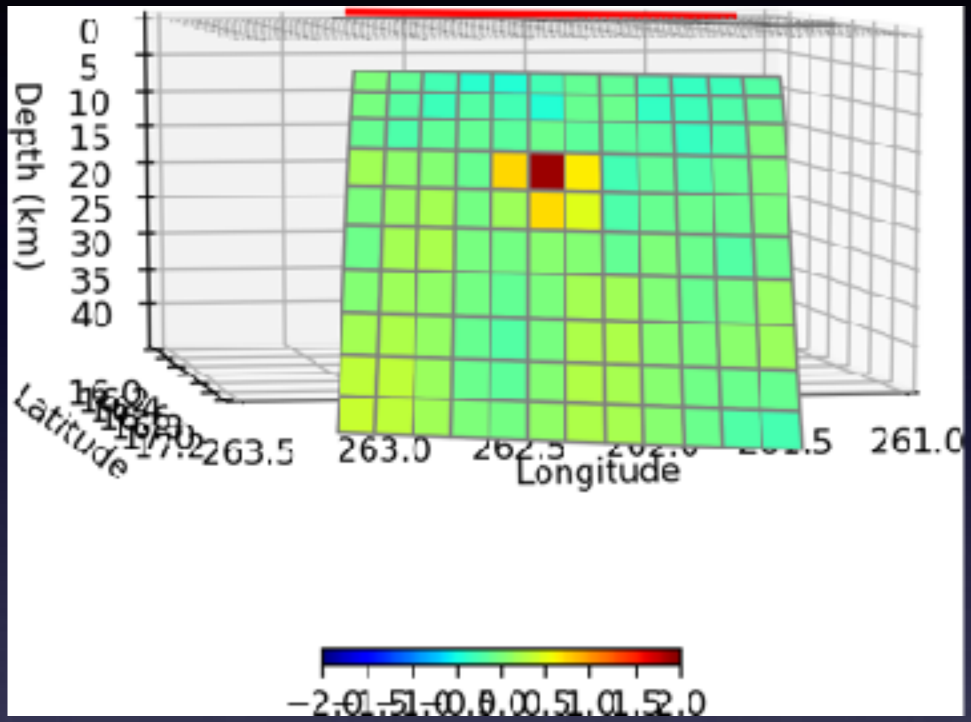
- Generated model fault from Slab1.0 database
- Includes down-dip curvature but not along-strike curvature
- Model fault v1: 20 km offset from trench, 160 km along-strike and 200 km down-dip
- 15x15 km patches
- CSI modeling

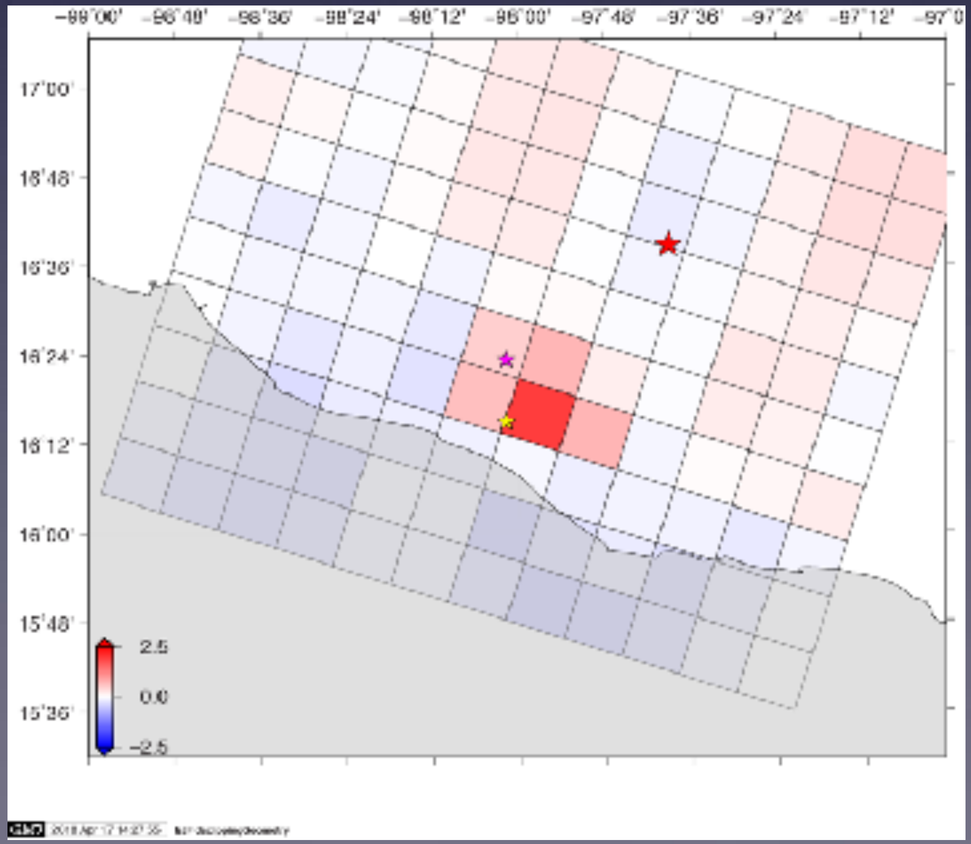




Pinotepa slip modeling

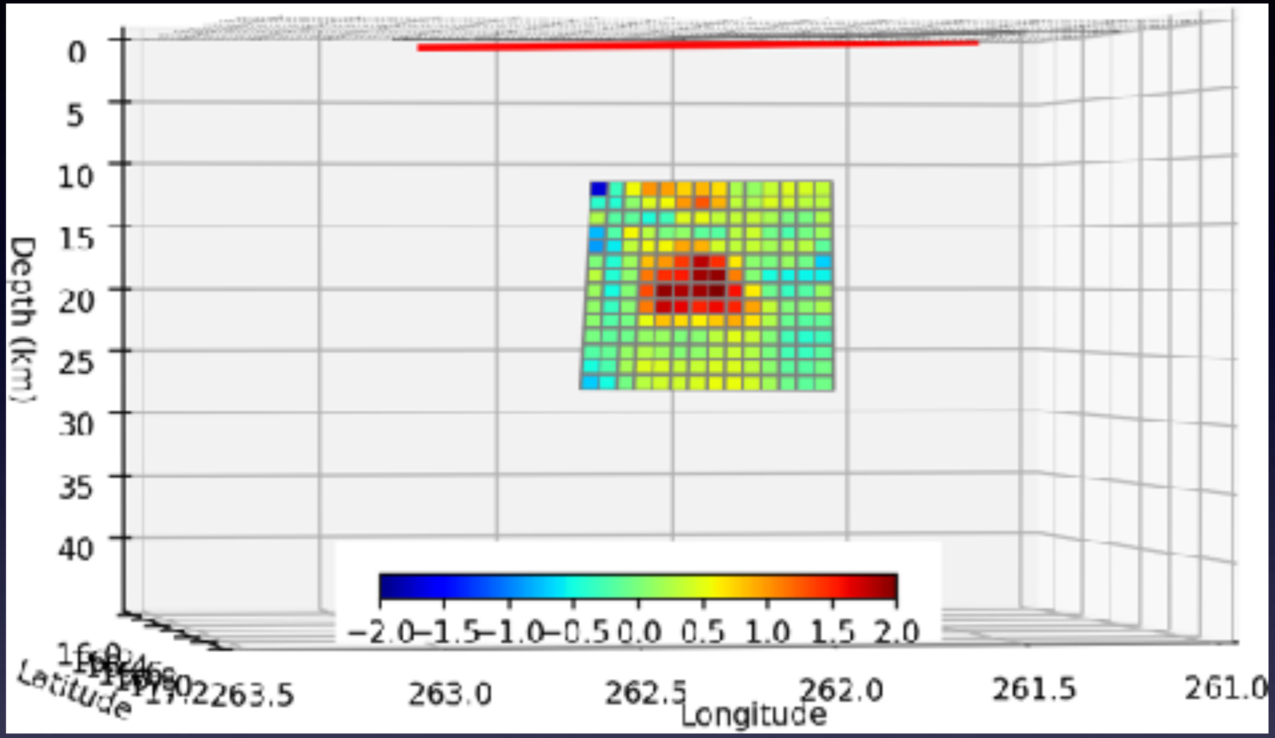
- Model fault v1 slip inversion with two Sentinel-1 interferograms (Desc. 143, Asc. 005)
- Dip-slip only, no positivity constraint
- Slip almost entirely in one 15x15 km patch near coast at 20–25 km depth
- USGS initial epicenter ~45 km NE (red star), SSN epicenter very close (yellow), GCCEL (Bergman et al.) relocation close (magenta star)

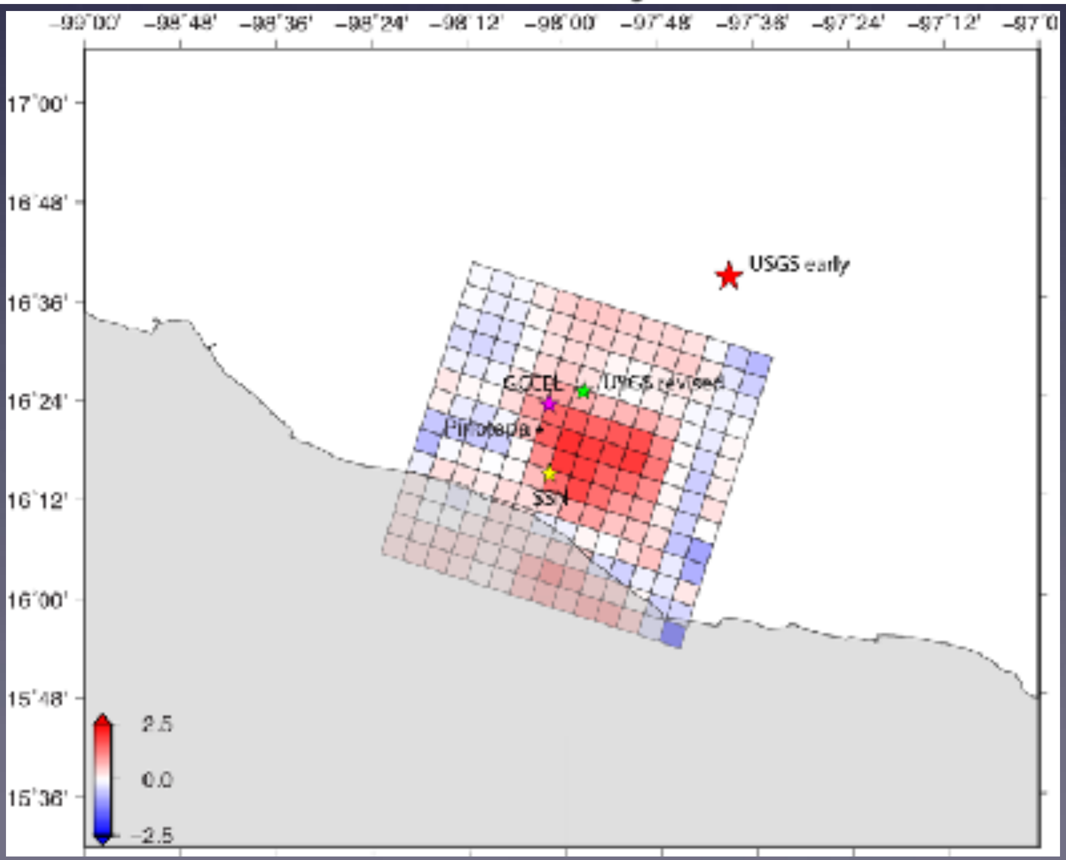




Pinotepa slip modeling

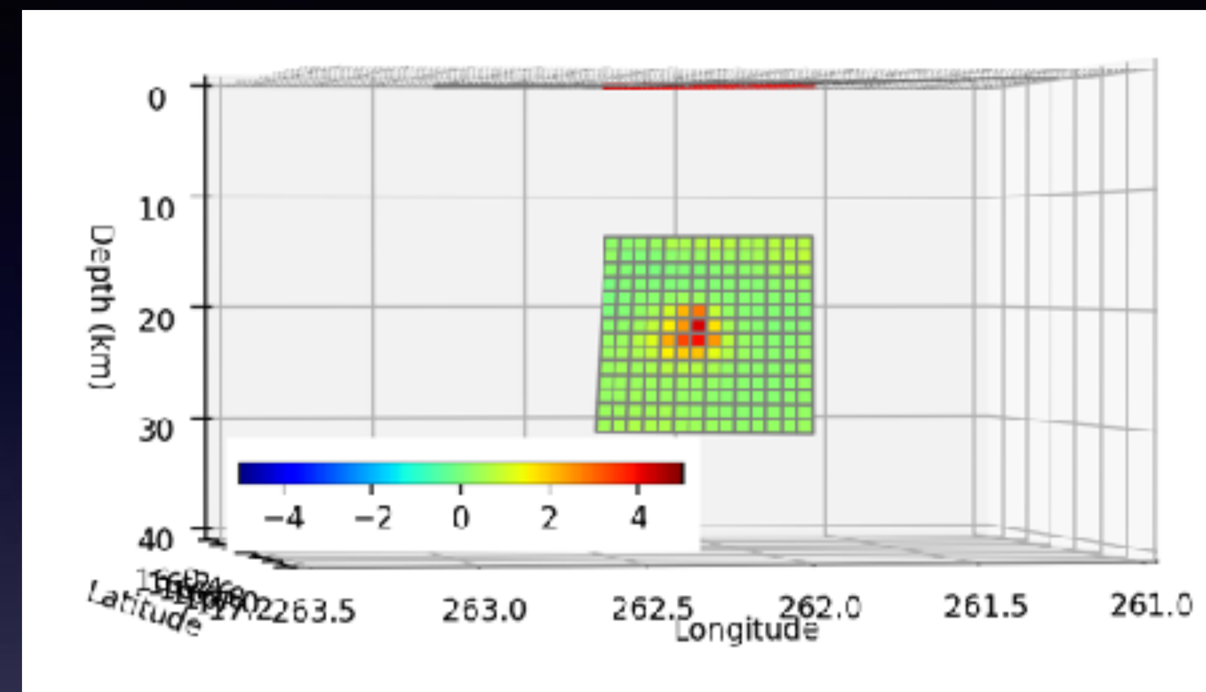
- Model fault v3 slip inversion with three Sentinel-1 ifgs (Desc. 143, Desc. 070, Asc. 005), ALOS-2 ifg (Desc. 150), GPS
- smaller model fault 70 x 70 km with 5x5 km patches from Slab1.0 database
- Dip-slip only, no positivity constraint, smoothing function of Radiguet et al. (2012)
- Depth 17–22 km with Slab1.0 geometry
- Slip about 10 by 20 km in this result, to be confirmed with full Bayesian inversion

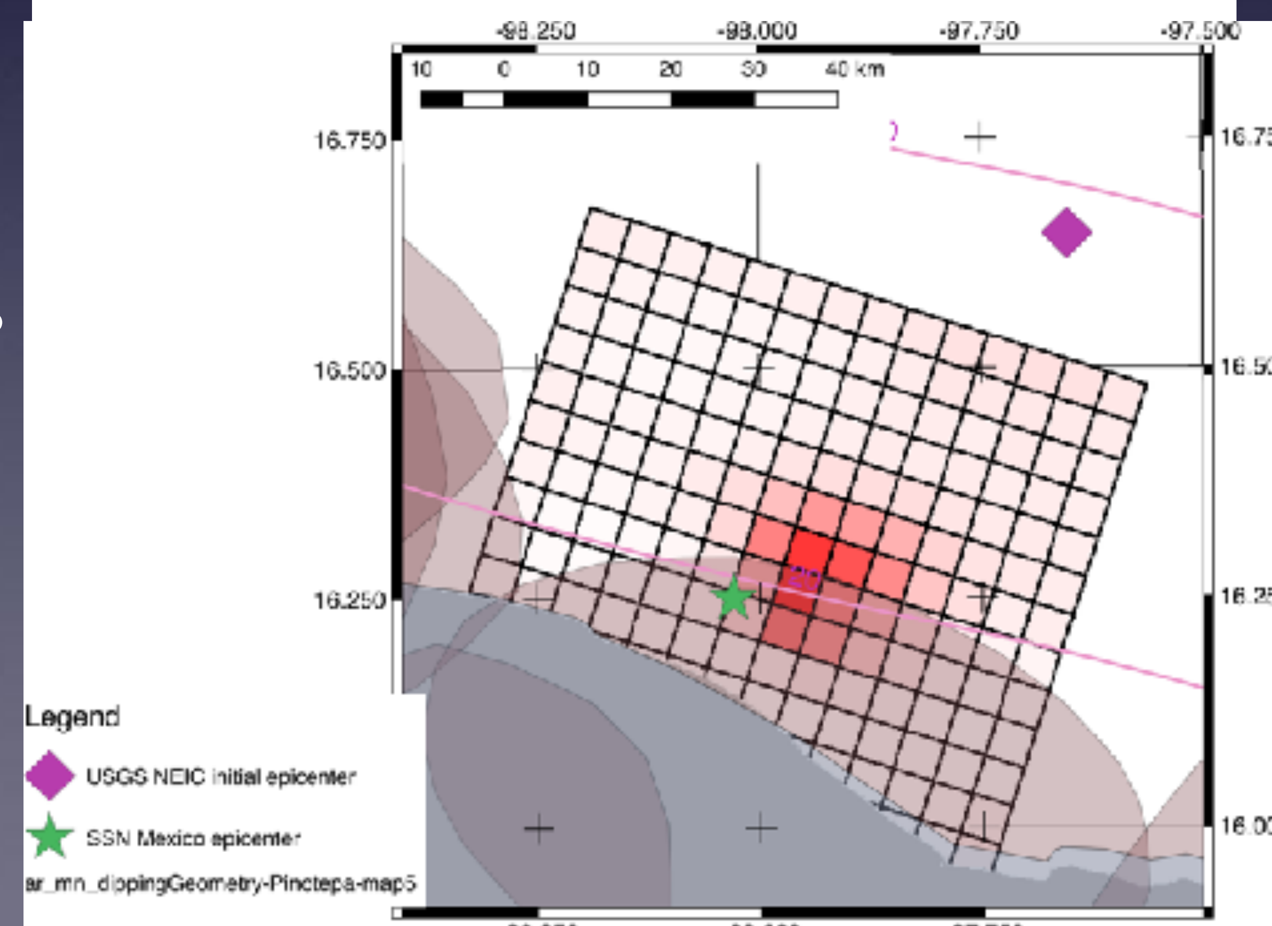




Pinotepa slip modeling

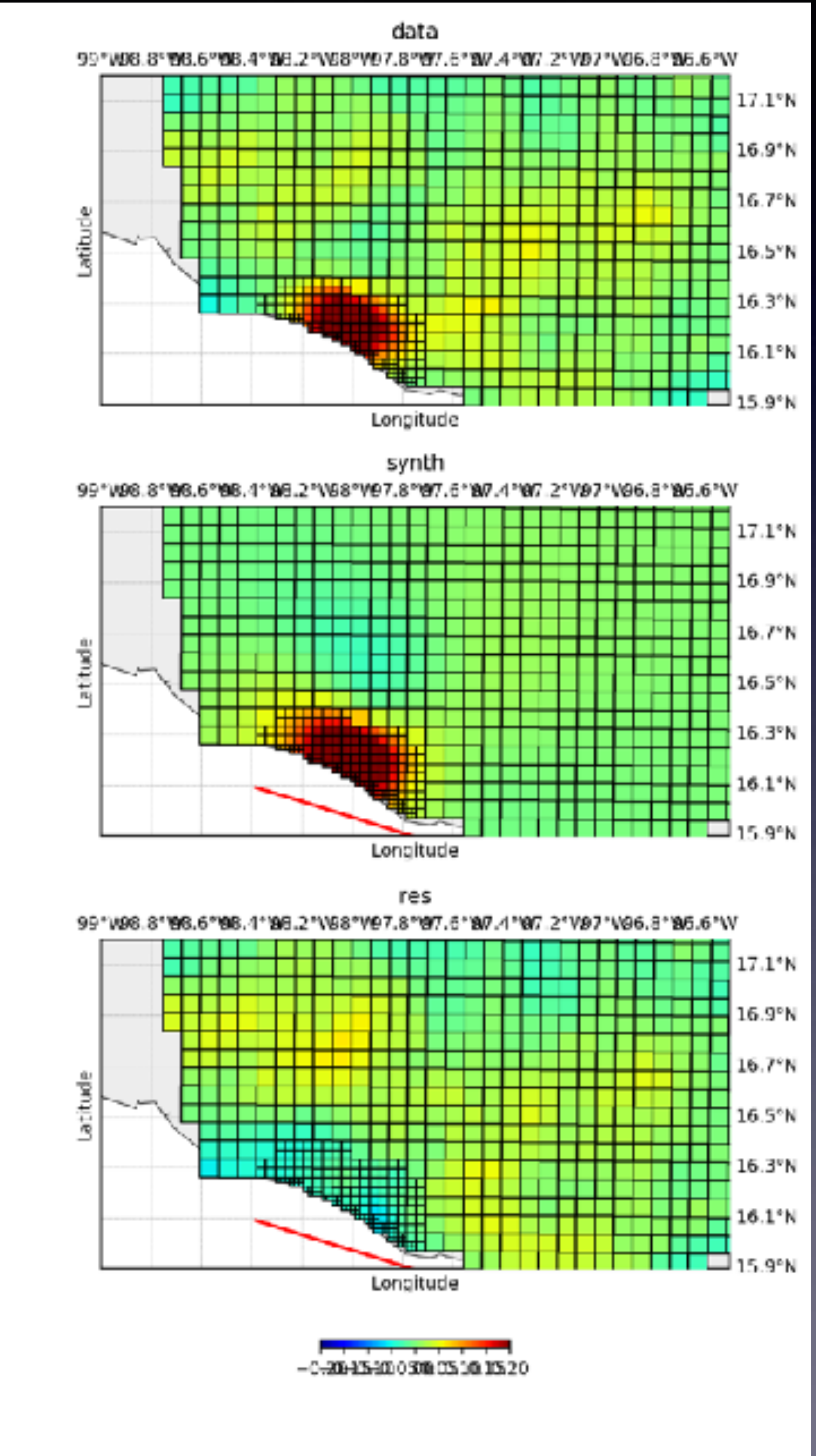
- Model fault v4 slip inversion with three Sentinel-1 ifgs (Desc. 143, Desc. 070, Asc. 005), ALOS-2 ifg (Desc. 150), GPS
- Smaller model fault 70 x 70 km with 5x5 km patches from Slab2.0 database (Hayes et al., 2018)
- Depth of slip 20–25 km with Slab2 geometry
- Slip parallel to W-phase CMT slip (-158° azimuth)
- Full Bayesian inversion with AlTar 1.1, uniform prior for along-rake slip [-0.1, 20 m] and Gaussian prior for rake-perpendicular σ=0.8 m





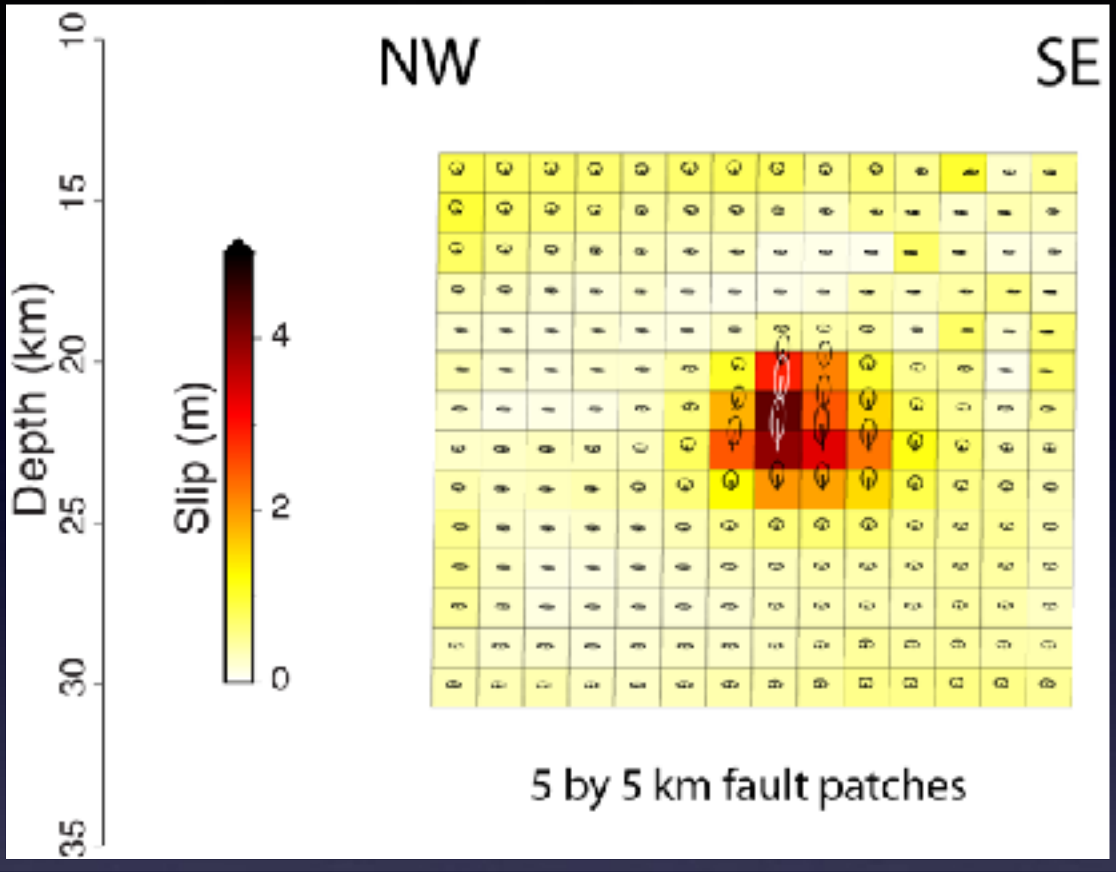
Pinotepa slip modeling

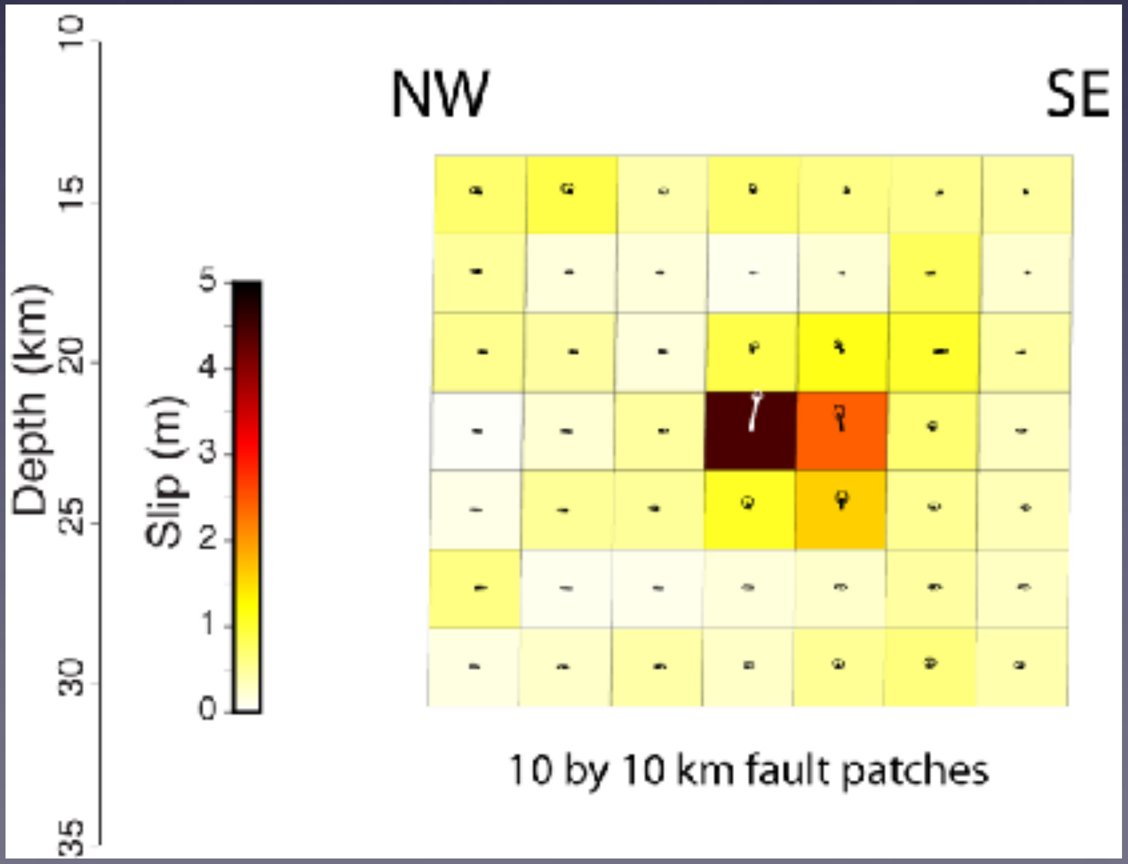
- Model fault v4 AlTar slip inversion with three Sentinel-1 ifgs (Desc. 143, Desc. 070, Asc. 005), ALOS-2 ifg (Desc. 150), GPS
- Excellent fit to InSAR data—example Sentinel-1 Ascending track 005
- Downsampled data (top), synthetic (middle), residual (bottom)
- Residuals likely all atmospheric noise



Pinotepa slip modeling

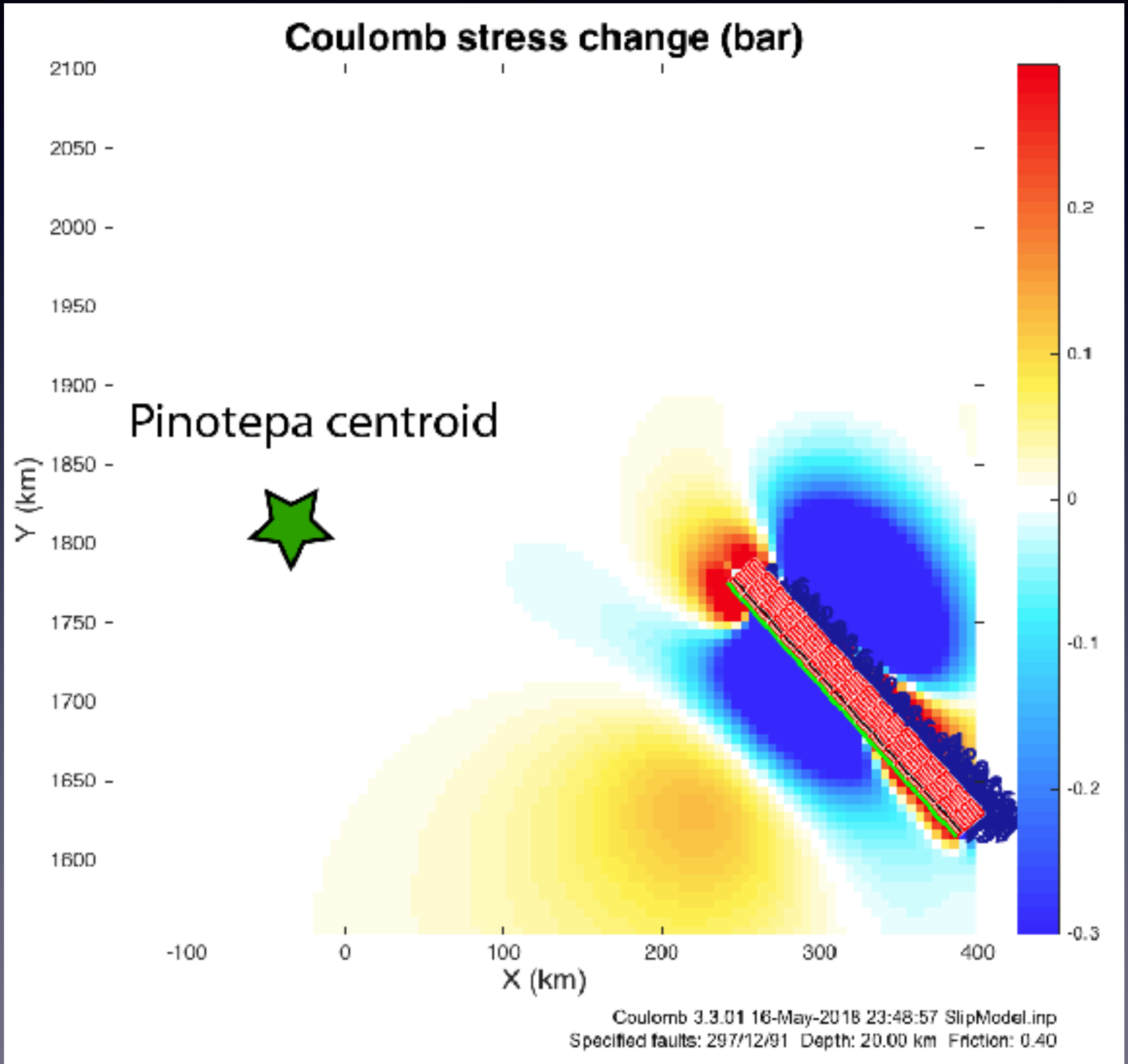
- AlTar slip inversion with 5x5 km patches (top) shows high slip uncertainty on each small patch
- AlTar slip inversion with 10x10 km patches (below) shows much lower uncertainty of slip on coarser patches
- slip area likely very compact ~20 km along strike and 10-15 km down dip
- Both models show greatest slip at depth ~22 km, based on Slab2 megathrust geometry



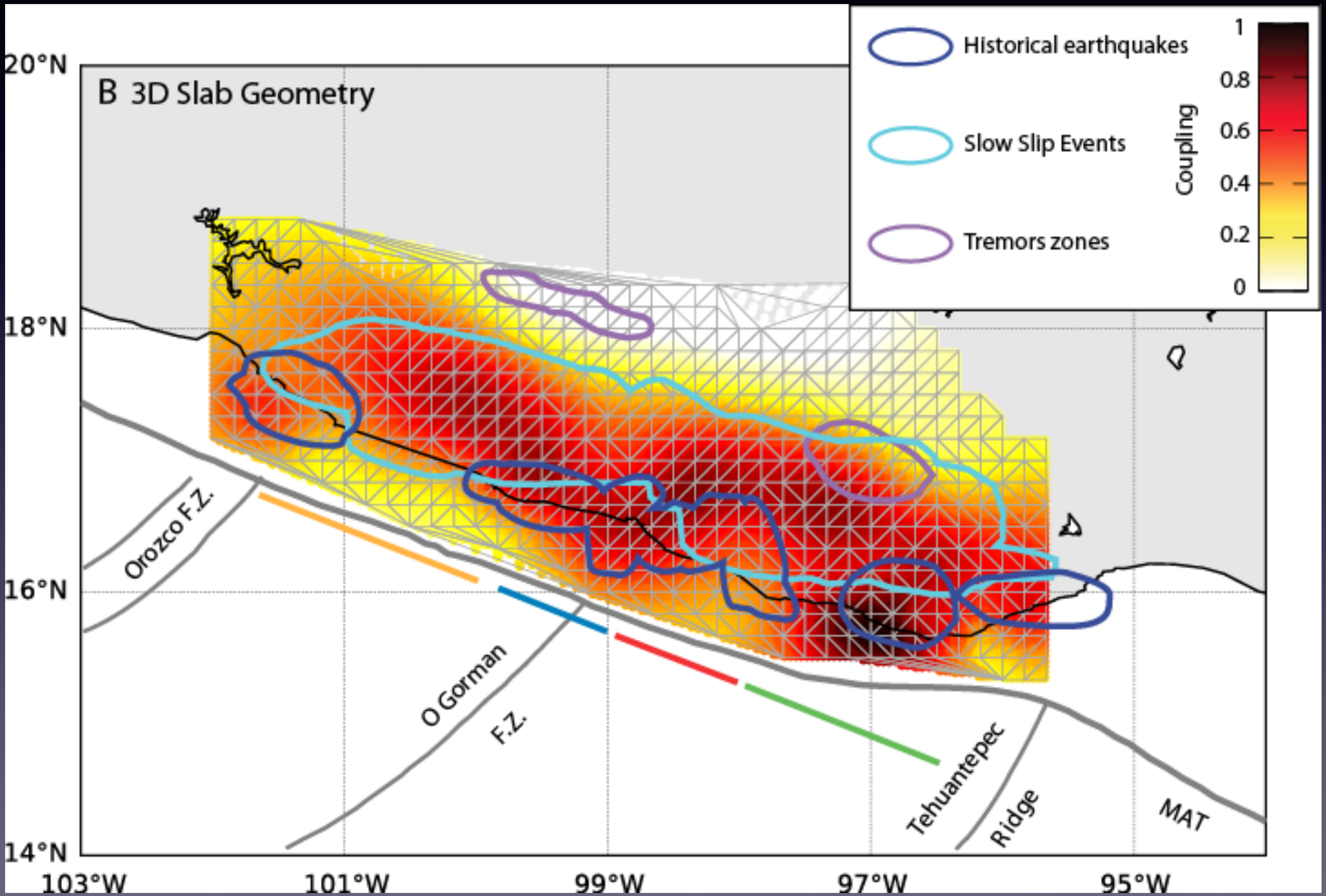


Coulomb stress change

- Coulomb static stress change from Tehuantepec quake for thrust faults strike/dip/rake 297°/12°/91° like Pinotepa CMT
- Map at depth 20 km
- Increased Coulomb stress only very close to Tehuantepec earthquake
- No significant static stress change at Pinotepa hypocenter

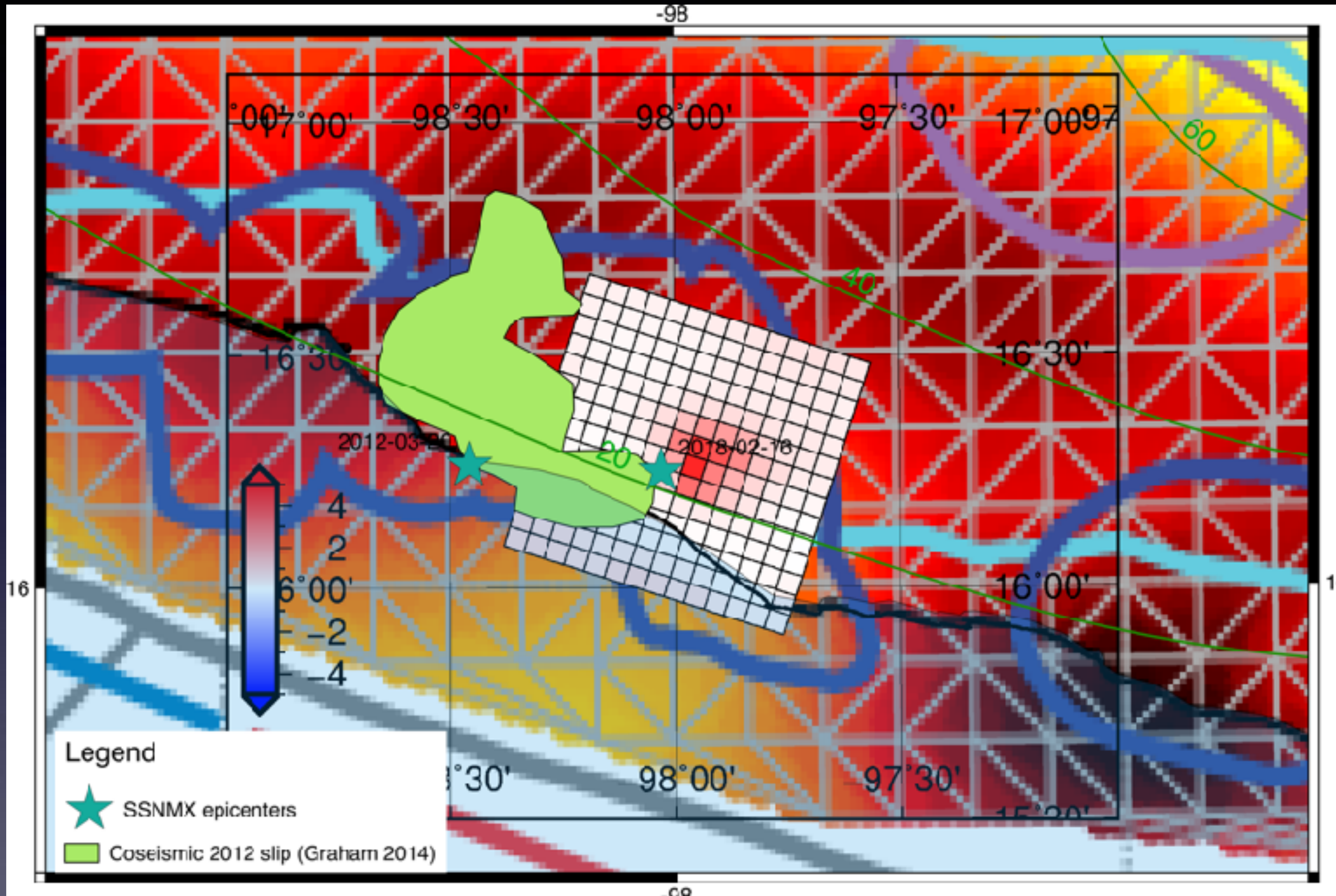


Oaxaca megathrust coupling



- Rousset et al. (2015) Pure Appl. Geoph. estimate from GPS

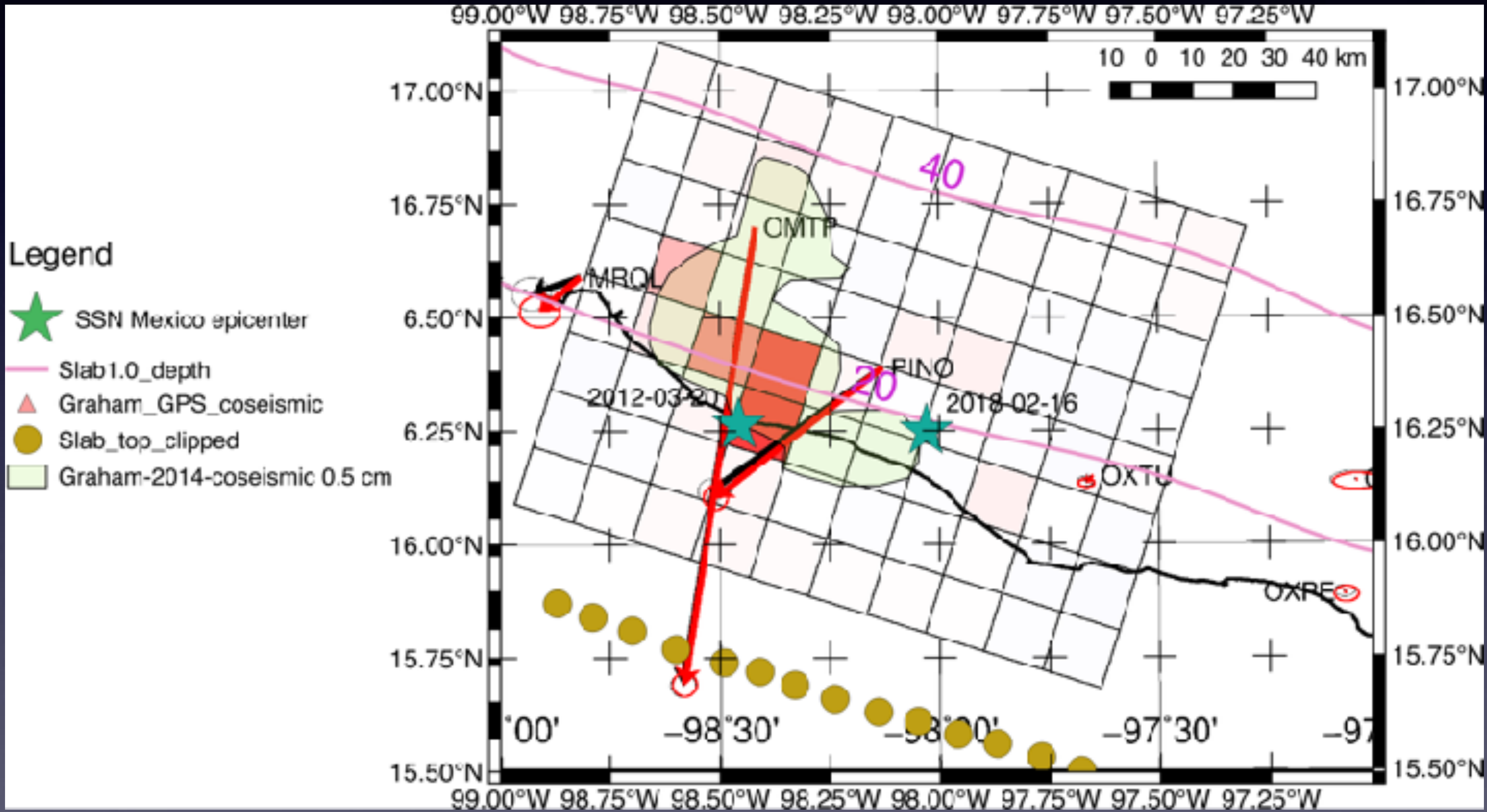
Oaxaca megathrust coupling



- 2018 M7.2 Pinotepa quake ruptured area that overlaps with slow-slip event zone (cyan), in partial coupling zone of Rousset et al. (2015) (background color)
- 2018 slip just east of 2012 M7.1 earthquake slip from Graham et al. (2014) (green)

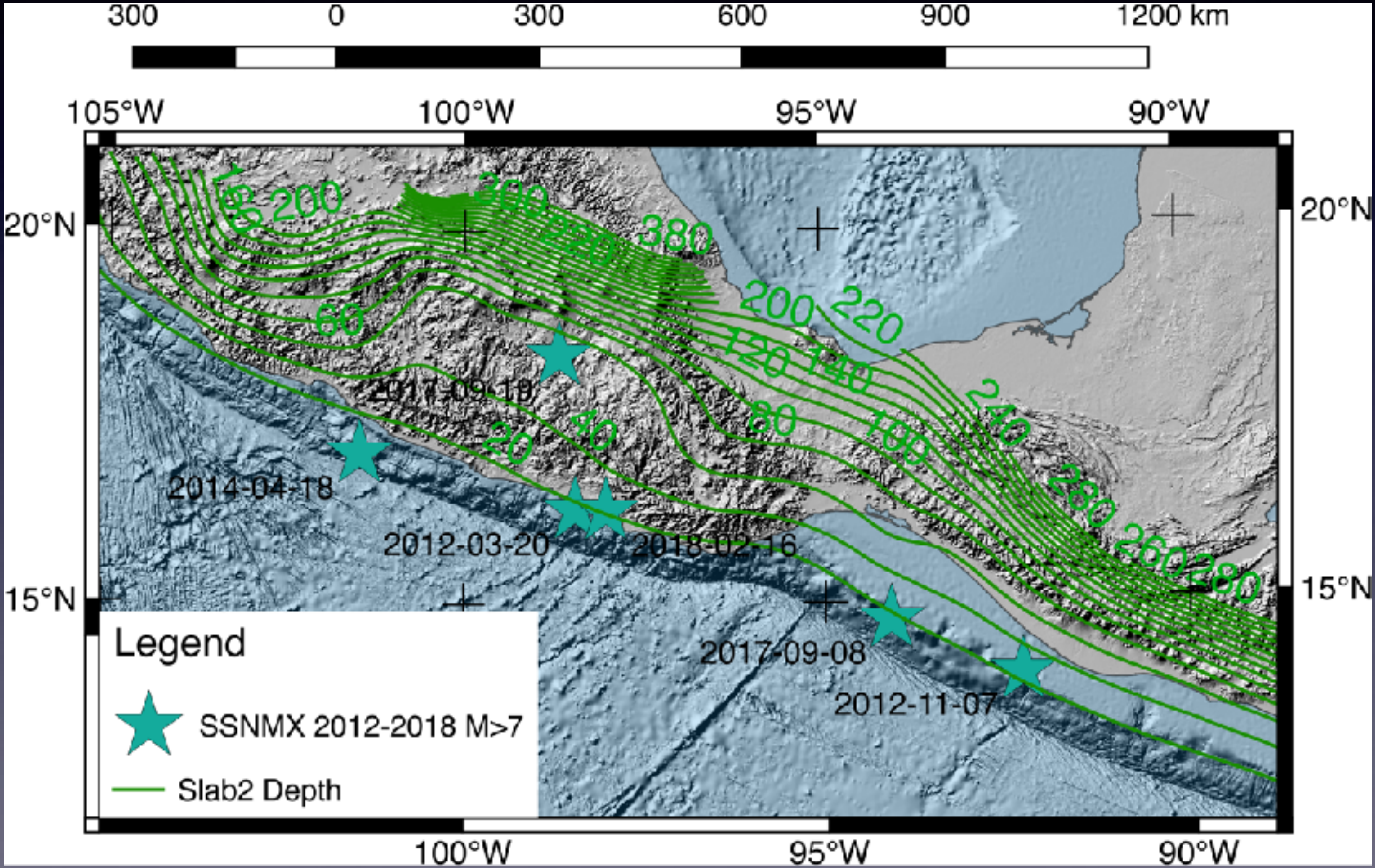
2012 Ometepec EQ slip modeling

- 20 March 2012 Mw 7.4 megathrust earthquake
- AlTar slip inversion with model fault from Slab2.0 database
- 15x15 km patches
- GPS offsets from Graham et al. (2014)
- High slip likely on central part of previous slip model
- No overlap with 2018 earthquake slip



Graham, S. E., C. DeMets, E. Cabral-Cano, V. Kostoglodov, A. Walpersdorf, N. Cotte, M. Brudzinski, R. McCaffrey, and L. Salazar-Tlaczani (2014), GPS constraints on the Mw = 7.5 Ometepec earthquake sequence, southern Mexico: coseismic and post-seismic deformation, *Geophys. J. Int.*, *199*(1), 200-218, doi:10.1093/gji/ggu167.

Central America Slab



Conclusions

- M8.2 Tehuantepec 8 Sept. 2017 quake normal-fault rupture through most of subducting Cocos plate, at least 150 and maybe 220 km long
- M6.1 Ixtepec 23 Sept. 2017 quake in Oaxaca compact 4 x 6 km rupture at ~10 km depth in upper plate crust, likely aftershock of M8.2
- M7.2 Pinotepa 16 Feb. 2018 quake in Oaxaca on megathrust very compact 10x20 km at depth ~20-25 km at edge of zone of many M7 quakes that may overlap SSEs
- Partial "coupling" likely has small locked patches like one that ruptured in 2018